Contents

	Preface	ix
1	Statistical concepts in reliability	1
1.1	Introduction	1
1.2	Reliability data	1 2
1.3	Repairable and nonrepairable systems	4
1.4	Component reliability and system reliability	7
1.5	The Binomial and Hypergeometric distributions	8
1.6	The Poisson process	10
1.7	The reliability literature	11
2	Probability distributions in reliability	12
2.1	Introduction	12
2.2	Preliminaries on life distributions	12
2.3	The exponential distribution	. 14
2.4	The Weibull and Gumbel distributions	16
2.5	The normal and lognormal distributions	22
2.6	The gamma distribution	28
2.7	Some other lifetime distributions	32
2.8	Censored data	36
2.9	Simple data analytic methods: no censoring	37
2.10	Data analytic methods: type II censoring	43
2.11	Data analytic methods: general censoring	45
3	Statistical methods for single samples	50
3.1	Introduction	50
3.2	Maximum likelihood estimation: generalities	50
3.3	Maximum likelihood estimation: illustrations	53
3.4	Tests and confidence regions based on likelihood	58
3.5	Remarks on likelihood-based methods	63
3.6	Goodness-of-fit	64
4	Regression models for reliability data	69
4.1	Introduction	69

vi Contents

1.2	Accelerated life models	70
1.3	Proportional hazards models	72
1.4	Proportional odds models	73
1.5	Generalizations	73
1.6	An argument from fracture mechanics	74
1.7	Models based on the Weibull distribution	76
4.8	An example: breaking strengths of carbon fibres and bundles	80
1.9	Other examples of comparing several samples	87
4.10	Weibull ANOVA	90
4.11	Buffon's beams: an historical example of reliability data	97
4.12	Concluding remarks	102
5	Proportional hazards modelling	104
5.1	Introduction	104
5.2	Analysis of the semiparametric PH model	105
5.3	Estimation of the survivor and hazard functions	108
5.4	Model checking	109
5.5	Numerical examples	110
6	The Bayesian approach	117
6.1	Introduction	117
6.2	A review of the Bayesian approach to statistics	117
6.3	Elements of Bayesian statistics	119
6.4	Further topics in Bayesian inference	124
6.5	Decision analysis	130
6.6	Bayesian analysis of reliability data	132
7	Multivariate models	137
7.1	Preliminaries	137
7.2	Some multivariate failure time distributions	138
7.3	Complete observation of T	141
7.4	Competing risks	147
8	Repairable systems	157
8.1	Introduction	157
8.2	Framework	157
8.3	ROCOF	158
8.4	Simple statistical methods	159
8.5	Non-homogeneous Poisson process models	164
8.6	NHPP with log-linear ROCOF	167
8.7	NHPP with ROCOF v_2	171

		Contents vii
8.8	Choice of NHPP model	174
8.9	Discussion	181
9	Models for system reliability	182
9.1	Introduction	182
9.2	Coherent systems	183
9.3	Estimation of reliability for coherent systems	188
9.4	Multi-state reliability theory	199
9.5	Load-sharing systems: the Daniels model	205
9.6	Extensions of the Daniels model	210
9.7	Time to failure	213
9.8	A more general model	215
9.9	Local load-sharing	218
9.10	Exact calculations	221
9.11	Approximations for local load-sharing systems	224
9.12	Statistical applications of load-sharing models	226
	Appendix: The Delta method	230
	References	233
	Author index	244
	Subject index	247